

# FUNCTIONAL MOVEMENT SCREEN™ (FMS™) SCORES DO NOT PREDICT OVERALL OR LOWER EXTREMITY INJURY RISK IN COLLEGIATE DANCERS

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## ABSTRACT

**Purpose:** Dance is a physically demanding activity, with 50-85% of dancers suffering injury during a single performance season. The majority of dancers' injuries are in the lower extremity (LE) and chronic in nature. These injuries often arise when causal factors are not identified early and addressed before they ultimately result in an injury. Practitioners often use movement screens such as the Functional Movement Screen™ (FMS™) to detect and quantify kinetic chain dysfunction. Prior researchers have suggested that these screens can stratify at-risk individuals and allow practitioners to devise targeted interventions to reduce their injury risk. However, whether the FMS™ can identify at-risk dancers remains unclear. Thus, the purpose of this study was to examine whether FMS™ scores predicted injury risk in collegiate dancers.

**Methods:** In this prospective study, 43 collegiate dance majors (34 female, 9 male;  $18.3 \pm 0.7$  yrs;  $163.9 \pm 7.3$  cm;  $60.8 \pm 8.1$  kg) in a program which emphasizes modern dance were scored on the seven FMS™ movements (scale 0-3, total maximum score = 21) where 3 = movement completed without compensation, 2 = movement completed, but with compensation(s), 1 = unable to complete movement, 0 = pain during movement or during clearing tests as described in prior literature at the start of the academic year. An in-house certified athletic trainer documented dancer's overall and LE injuries over an academic year (40 weeks). Separate Receiver Operator Characteristic (ROC) curve analyses examined whether composite FMS™ score predicted (1) Overall or (2) LE injury status.

**Results:** The subjects FMS™ scores were  $16.2 \pm 1.7$  (range = 11–19). Twenty dancers were injured, whereas 23 remained injury-free. Injured dancers had 55 overall (1.28 injuries/dancer) and 44 LE injuries (1.02 LE injuries/dancer). FMS™ score did not predict overall (AUC = .28, SE = .08,  $p = .02$ , 95% CI = .13-.43) or LE injury risk (AUC = .38, SE = .1,  $p = .21$ , 95% CI = .21-.56).

**Discussion:** While nearly half of the dancers in this group suffered from injury over the year, composite FMS™ scores did not predict overall or LE injury risk in collegiate dancers. Dancers face unique and challenging physical demands that distinguish them from traditional sport-athletes including greater ranges of movement during performance. Thus, the FMS™ may not be sensitive enough to distinguish 'appropriate' from 'excessive' mobility and adequately identify injury risk in dancers. Overall, it is suggested that practitioners should use caution before using the FMS™ as a primary screening mechanism to identify collegiate dancers at overall or LE injury risk.

**Level of Evidence:** 2

**Key Words:** Aesthetic Athlete, Dance Medicine, Injury Prevention, Movement System, Screening Tool

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## INTRODUCTION

Distinct due to its aesthetic nature and expressivity, dance remains a physically demanding activity, with 50-85% of dancers suffering injury during a single performance season.<sup>1-4</sup> A majority of these injuries are to the lower extremity and chronic in nature.<sup>5-7</sup> These overuse injuries are thought to arise from the cumulative effects of microtrauma, manifesting when causal factors, such as inefficient or compensatory movement patterns and altered biomechanics, are not identified and addressed.<sup>8-10</sup>

The Functional Movement Screen™ (FMS™) is a popular screening tool consisting of seven movement tasks intended to identify and quantify appropriate, dysfunctional, and/or painful movement.<sup>8,11,12</sup> It was designed to challenge the interactions of kinetic chain mobility and stability necessary for adequate performance of basic, functional movement patterns; bridging the gap between individual muscle or joint assessments such as range of motion or manual muscle testing and performance testing.<sup>8,11,13,14</sup> Given the cost and consequences of musculoskeletal injury and its sequelae,<sup>15,16</sup> common applications of the FMS™ have included attempts to predict performance<sup>17-19</sup> and injury.<sup>12,20-24</sup> While other uses exist, the ability to stratify individuals at higher risk of potential injury and allow for targeted interventions to address identified deficits would be beneficial to the sports medicine community and beyond. Indeed, the FMS™ has been used in this capacity among athletes at the high school,<sup>25</sup> collegiate,<sup>20,23,26,27</sup> and professional levels.<sup>12,28</sup> Active populations where reduction in injury rates would also prove valuable, such as in public safety and the military have also examined the potential of the FMS™ to predict injury.<sup>29-31</sup>

Conflicting reviews of the predictive value of the FMS™ may be due to the variety in sample sizes, settings, injury definitions, and statistical techniques used in various studies.<sup>16,32,33</sup> One population where proper identification of functional movement insufficiencies with a screen such as the FMS™ and appropriate subsequent intervention could have a significant and positive impact is that of dancers. The etiology of some dance injuries may stem from the unique demands inherent to the activity itself, such as the repetitive movement patterns and extreme ranges of motion often required of the performer. The overwhelming

majority of these injuries manifest as chronic issues in the lower extremity. Overall, despite dancers being an active population at risk for sustaining injury, and regardless of extensive research using the FMS™ to screen for risk of injury, it remains unknown whether or not this tool is capable of predicting injury among collegiate dancers. Thus, the objective of this study was to examine whether FMS™ scores predicted injury in collegiate dancers.

## METHODS

### Experimental Approach to the Problem

This research utilized a prospective cohort study design to examine composite FMS™ scores and documented injuries in collegiate dancers over a 40-week academic year. Injuries were recorded by an in-house certified athletic trainer. The FMS™ testing was performed in a single session as part of an annual physical fitness assessment. The same investigator performed the FMS™ on all participants. This tester was certified in using the FMS™ and had two years' experience using the tool as part of standard practice of care.

### Participants

Forty-three collegiate dancers (34 female, 9 male; age =  $18 \pm 0.7$  years; height =  $162.6 \pm 5.9$  cm; mass =  $59.4 \pm 7.1$  kg, dance experience =  $12.7 \pm 3.8$  years) participated in the study. Participants were dance majors in a program that emphasizes modern dance, but all dancers had prior experience in other dance styles including, but not limited to ballet, jazz, and hip-hop dance. Participants danced  $25.6 \pm 5.6$  hours weekly (including dance classes, rehearsals, and performances). Researchers collected dancers' anthropometric data; age was recorded to the nearest whole year, height was measured to the nearest millimeter using a Seca 216 Stadiometer (Scale Co. Inc, Brooklyn, NY), and body mass to the nearest 0.1kg using a digital scale (Precision Digital Bathroom Scale, HealthTools LLC, Mahwah, NJ). The George Mason University's Institutional Review Board approved the study, and all participants gave their written, informed consent before taking part in the study.

### Injury Definitions

Injuries were defined based on prior recommendations for surveillance of dance injuries as 'any

physical complaint sustained by a dancer resulting from company performance, rehearsal, or technique class and resulting in a dancer injury report and triage, irrespective of the need for medical attention or time-loss from dance activities'.<sup>5,34</sup> All injury data were recorded over a 40-week academic year by the healthcare team. Anatomical locations of all injuries were specified, and we included both overall and LE injuries (toes-foot, ankle-lower leg, knee, and hip-thigh) in the present study. The same athlete may have incurred multiple injuries throughout the academic year, potentially at the same anatomical location.

### The Functional Movement Screen™ (FMS™)

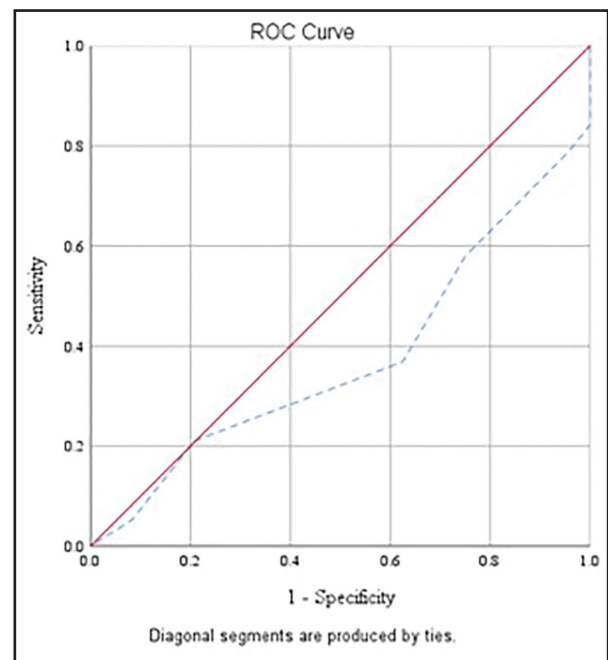
The same, certified investigator performed the FMS™ screen for all participants. The FMS™ was conducted based on previously published protocols.<sup>8,11</sup> Briefly, researchers examined the seven FMS™ movements: Deep Squat, Hurdle Step, In-Line Lunge, Active Straight Leg Raise, Rotary Stability, Shoulder Mobility, and Trunk Stability Push-Up. All seven tasks were able to be executed up to three times and the best of the three trials was scored. Of the bilateral tests, if there was a difference in scores from left to right side, the lower of the two scores was accepted and the asymmetry noted. Researchers also conducted bilateral Yocum's tests, spinal flexion, and spinal extension clearing tests to assess for pain indicative of pathology. Positive clearing tests override FMS™ scores for their associated movement tasks, as a score of 0 is given if pain is indicated. Each movement was scored on a 0-3 scale, where 3 = movement completed as requested without compensation, 2 = movement completed, but with compensation(s), 1 = unable to complete movement as requested, 0 = experienced pain during movement or clearing test, for a total composite score of up to 21.

### Statistical Analyses

Separate Receiver Operator Characteristic (ROC) curve analyses examined whether FMS™ scores could predict (1) overall or (2) LE injury status. An 0.05 *a priori* alpha level was set for all tests, and SPSS 24.0 was used to conduct all analyses.

## RESULTS

Dancers scored  $16.2 \pm 1.7$  on the FMS™ (range 11-19). Over the study period 20/43 dancers suffered an



**Figure 1.** Receiver Operator Characteristics (ROC) Curve examining ability of composite FMS™ scores to predict overall injury risk in collegiate dancers

injury. Injured dancers had 55 overall (1.28/dancer) and 44 LE injuries (1.02/dancer). The FMS™ score did not predict either overall (AUC = .28, SE = .08,  $p = .02$ , 95% CI = .13-.43) or LE injury risk (AUC = .38, SE = .1,  $p = .21$ , 95% CI = .21-.56). (Figures 1-2)

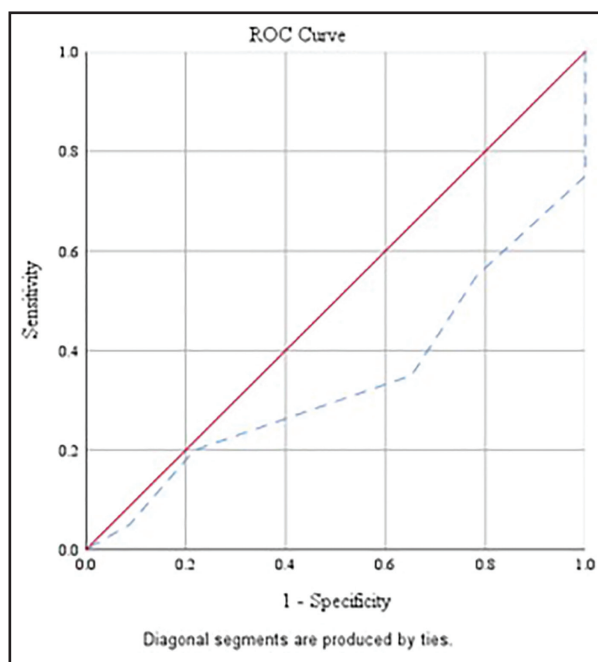
## DISCUSSION

### Primary Findings

Given that dancers are at risk for injury, and with prior reports suggesting the use of the FMS™ to identify at-risk individuals, researchers examined whether the FMS™ could predict injury risk in collegiate dancers. However, FMS™ scores did not demonstrate the ability to predict overall or LE injury risk in this cohort of collegiate dancers.

### Comparisons with Prior Literature

Despite some prior literature suggesting that higher composite FMS™ scores were associated with decreased injury risk,<sup>12,20</sup> FMS™ scores did not predict overall or lower extremity injury risk in the current group of university dancers. These findings are consistent with other reports that suggest the FMS™ is not useful as a predictor of musculoskeletal injury risk.<sup>21,22,24,35,36</sup> While challenges exist with



**Figure 2.** Receiver Operator Characteristics (ROC) Curve examining ability of composite FMS™ scores to predict lower extremity injury risk in collegiate dancers

interpretation of the composite FMS™ score,<sup>16</sup> generally, previous authors have suggested that those who achieve a composite FMS™ score above 14 have a decreased risk of experiencing injury compared to those who score at or below this level.<sup>6,7,9,12,20,27,29,31</sup> Due to the differences in statistical methodology, population, and injury definitions used in various studies, whether or not there is a ceiling of discriminative ability at a composite score of 14 remains unknown.

While some studies have used slightly higher cut-off scores,<sup>13,14,37</sup> the findings are mixed. Prior researchers found that a composite FMS™ score below 17 was associated with an increased risk of sustaining injury,<sup>26</sup> whereas others<sup>21,24</sup> using cut-off scores of 17 and 15, respectively, found limited prognostic accuracy – indicating that FMS™ aggregate score was not useful in predicting musculoskeletal injuries. At least one cut-off point below the more commonly used score of 14 has also been reported in a sample of professional rugby players.<sup>10</sup> It is worth noting that this lower cut-off score of 13 was found by considering only severe injuries that excluded player participation in either practice or competition for at least 28 days.<sup>10</sup>

A more recent systematic review with meta-analysis concluded the strength of association between composite FMS™ scores and subsequent injury does not support its use in a predictive capacity.<sup>22</sup> In agreement with this review, this study also found that composite FMS™ scores were not able to predict injury risk in our sample of collegiate dancers.

### FMS™ Scoring

While reliability has been well-established with scoring the FMS™,<sup>6,32,37–39</sup> significant concerns remain regarding the validity of the instrument.<sup>22,32</sup> Validity is defined in this case based on the ability of the screening tool to identify deficiencies in movement patterns.<sup>13,14,32</sup> Although not designed with this specific application in mind, the composite score is often used in evaluating injury risk.<sup>7,33</sup> This composite FMS™ score utilized by practitioners to determine those at higher risk for injury ranges from 0–21 and, as previously described, is the summed total of seven individual movement tasks.<sup>9,40</sup> This scoring interpretation assumes a stable factor structure and unidimensionality of the FMS™.<sup>7,41,42</sup>

The factor structure of a scale, particularly one being interpreted as single, unidimensional construct, is important and can be evaluated using exploratory factor analysis.<sup>7,40</sup> A recent study found the FMS™ composite score did not present a gestalt measure of movement quality.<sup>43</sup> This observation – and the observations by multiple other authors examining different populations (youth athlete, elite athlete, and military personnel) – call into question the construct validity of a single summed value, providing evidence against the unidimensionality of the FMS™.<sup>40,42–44</sup> Overall, these findings caution against traditional use of a composite FMS™ score as a predictor for future injury risk.

### Limitations and Future Recommendations

There are limitations in this study. The sample is from a single institution and thus may not be representative of all dancers and genres at the collegiate level. Ideally, examination of multiple sites and programs, different genres, and varying levels of dance would provide better ability to generalize results. A strength of this study is that we had the same, trained individual score the FMS™ for all participants. This individual was also part of the healthcare team that



kept in-house medical care records throughout the duration of the study.

A previously examined FMS™ confounding factor<sup>45</sup> that may have impacted this study is that of performers' knowledge, given the sample of collegiate dancers. Participants adapt their movement based on their understanding of the instructions given and their experience or familiarity with the tasks.<sup>45</sup> Specifically, while the verbal instructions of "descend as far as you can into a squat position"<sup>13</sup> may be adequate for certain athletes to perform the requested action, the same might not be true for another group of participants (e.g. dancers without the training experiences more common to traditional sports like football or basketball). How this factor may have affected FMS™ scores warrants further study.

### PRACTICAL APPLICATIONS

Movement screening tests such as the FMS™ have gained popularity as simple, objective methods to quantify dysfunctional movement patterns and determine injury risk.<sup>40</sup> These screening tools are suggested to aid in performance enhancement and educational efforts, as well as assist in making return-to-play or return-to-performance decisions. Dancers face unique physical demands intrinsic to their craft which distinguishes them from traditional athletes, more commonly the subjects of studies that utilize the FMS™ to predict injury. For example, greater ranges of movement are often necessary to properly perform; however, the FMS™ is unable to distinguish 'appropriate' from 'excessive' mobility - something which would be important to identify in this population. These findings suggest the FMS™ may not be sensitive enough to adequately capture dysfunctional movement predictive of injury in this particular population. The implications of these results suggest that practitioners should exercise caution before using the FMS™ as a measure to identify dancers at increased injury risk.

### CONCLUSIONS

Overall, although nearly half of the dancers suffered from injury, composite FMS™ score did not predict overall or LE injury risk in collegiate dancers. Thus, the FMS™ may not be sensitive enough to adequately identify injury risk in collegiate dancers. Practitioners should use caution before using

the FMS™ as a primary screening mechanism to identify collegiate dancers at increased overall or LE injury risk. Further, it is recommended that the practical use of the FMS™ be limited to assessment of movement quality in dancers.

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